Estimating the Costs and Benefits of Adaptation to Extreme Precipitation:

Duluth MN and Toledo OH

NATIONAL ADAPTATION FORUM
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Overview

- Objectives and Methodology

- How Methodology was Applied in Duluth and Toledo

- Lessons Learned to Date

Objectives

- Identify the most cost effective stormwater management practices taking into account:
  - Future precipitation (2035)
  - Green infrastructure options
  - Future land use/land management options
- Develop a framework that can be used to inform future land use and stormwater infrastructure investments in other communities

Adaptation Meets Hazard Mitigation

- Solving today's problems to be economically and environmentally sustainable for realities of the 21stC
  - Immediacy of issue ~$2Billion/year for federally funded water infrastructure
  - Development pressure: once open space is developed, GI options become much more limited

Methodology

Evaluate:

1. Current rainfall with planned development (baseline)

2. Future rainfall (2035) with planned development

3. Current rainfall with planned development modified with adaptive measures (GI)

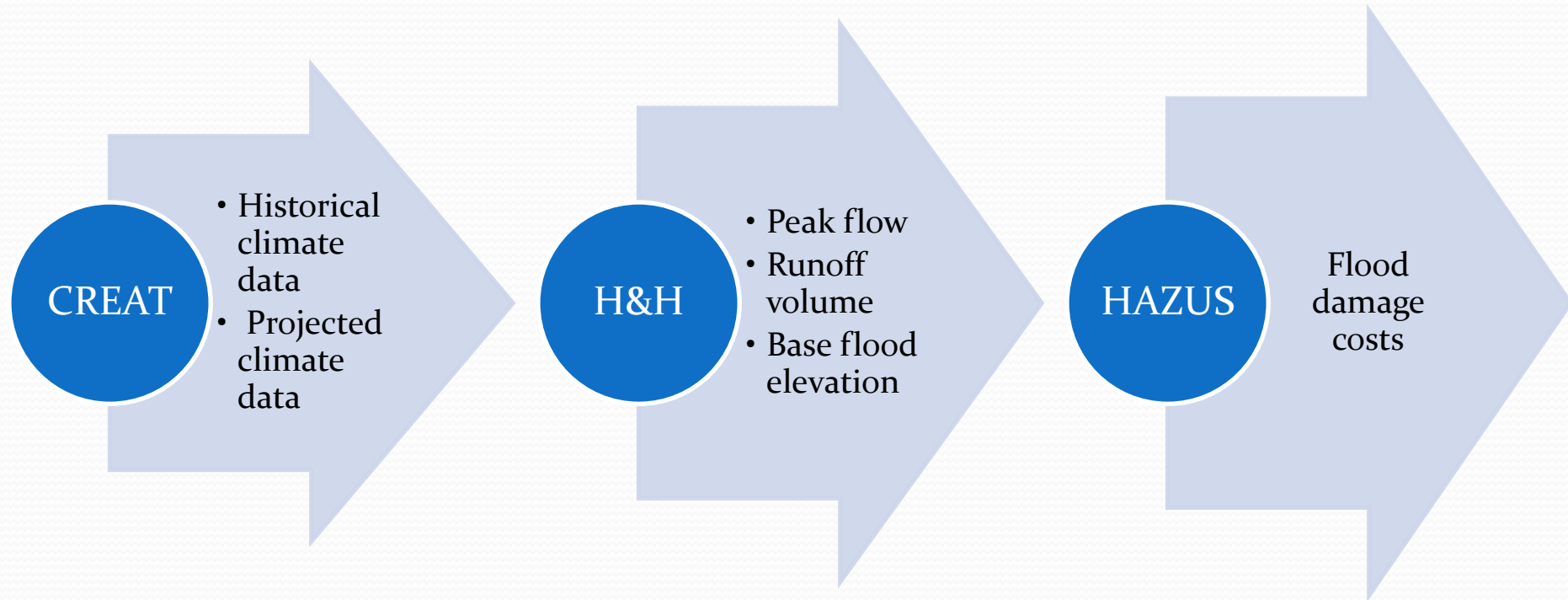4. Future rainfall (2035) with planned development modified with adaptive measures (GI)

Calculate:

Costs of flooding with and without adaption: *the business case for adaptive infrastructure*

Study Components – 5 Easy Pieces

- <u>Climate Prediction</u>: How much precipitation in 2035? (EPA's CREAT Model)

- <u>Hydrology and Hydraulics</u>: What are the resulting flood elevations and associated impacts? (Corps working with community models e.g., HEC, SWMM, SWAT)

- <u>Flood Damage Estimate</u>: What is the cost of the damage? (FEMA's HAZUS Model)

- <u>Planning</u>: What can be done to minimize damages? (Land Use and Gray-Green Infrastructure Options)

- <u>Economics</u>: What are the costs and benefits of the adaptation options? (Building on and expanding RFF methodology)

How do the Models Work Together?

CREAT
- Historical climate data
- Projected climate data

$\rightarrow$

H&H
- Peak flow
- Runoff volume
- Base flood elevation

$\rightarrow$

HAZUS

Flood damage costs

Economics

- Monetize primary and secondary costs based on HAZUS *(property damage)* outputs
- Estimate average annualized costs for a set of flooding events at different intensities
- Evaluate difference in cost under the four operating assessment scenarios
- Estimate co-benefits (water quality, recreation, fisheries) of green infrastructure for fuller cost accounting

Lower Fox River Basin, Wisconsin

Resources for the Future (2011)

Costs of Preserving open space in the East River Watershed Floodplain (compared to annualized cost of flooding @ build-out of $2.6 million)		
	Annualized Cost	Acres of Green Infrastructure
All parcels in floodplain	$5.1 million	7,406
Targeting Scenarios		
Parcels with >1 foot of water in 100-year flood	$3.7 million	4,646
Parcels accounting for 90% of acre-feet of flooding	$1.2 million	6,385
Parcels below median cost per acre-foot of flooding	$496,000	6,379

Tale of Two Cities

- Duluth - focus on damages from rarer, high intensity events
- Toledo - focus on damages from frequent, low intensity events

Adaption Options Considered in Duluth and Toledo

- Land Use Options
  - Property buy outs
  - Easements
  - Riparian buffer and floodplain restoration
  - Conservation of open space
  - Zoning changes

- Infrastructure Options
  - Porous pavement
  - Bio-retention
  - Rainfall capture
  - Blue/green roof
  - Grey infrastructure
  - Wetlands/floodplain restoration
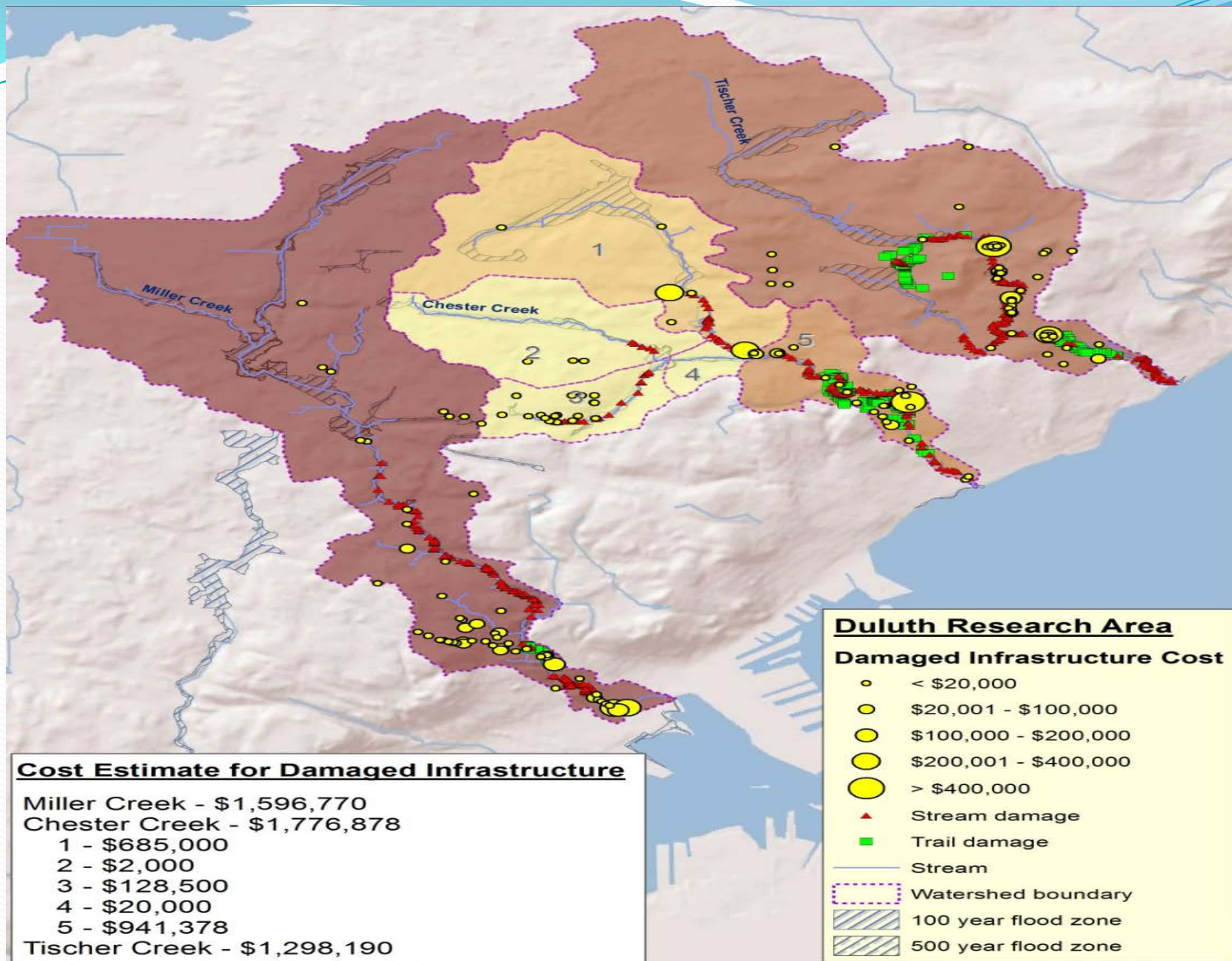 - Everything in between

Duluth: Issues & Considerations

- Unique geology: runoff is channeled into bedrock ravines that convey large volumes of runoff

- Minimal floodplains due to steep slopes

- Highly recreational use of sub-watersheds

- Aging and undersized infrastructure significantly contributes to flooding (dates back to 1880s)
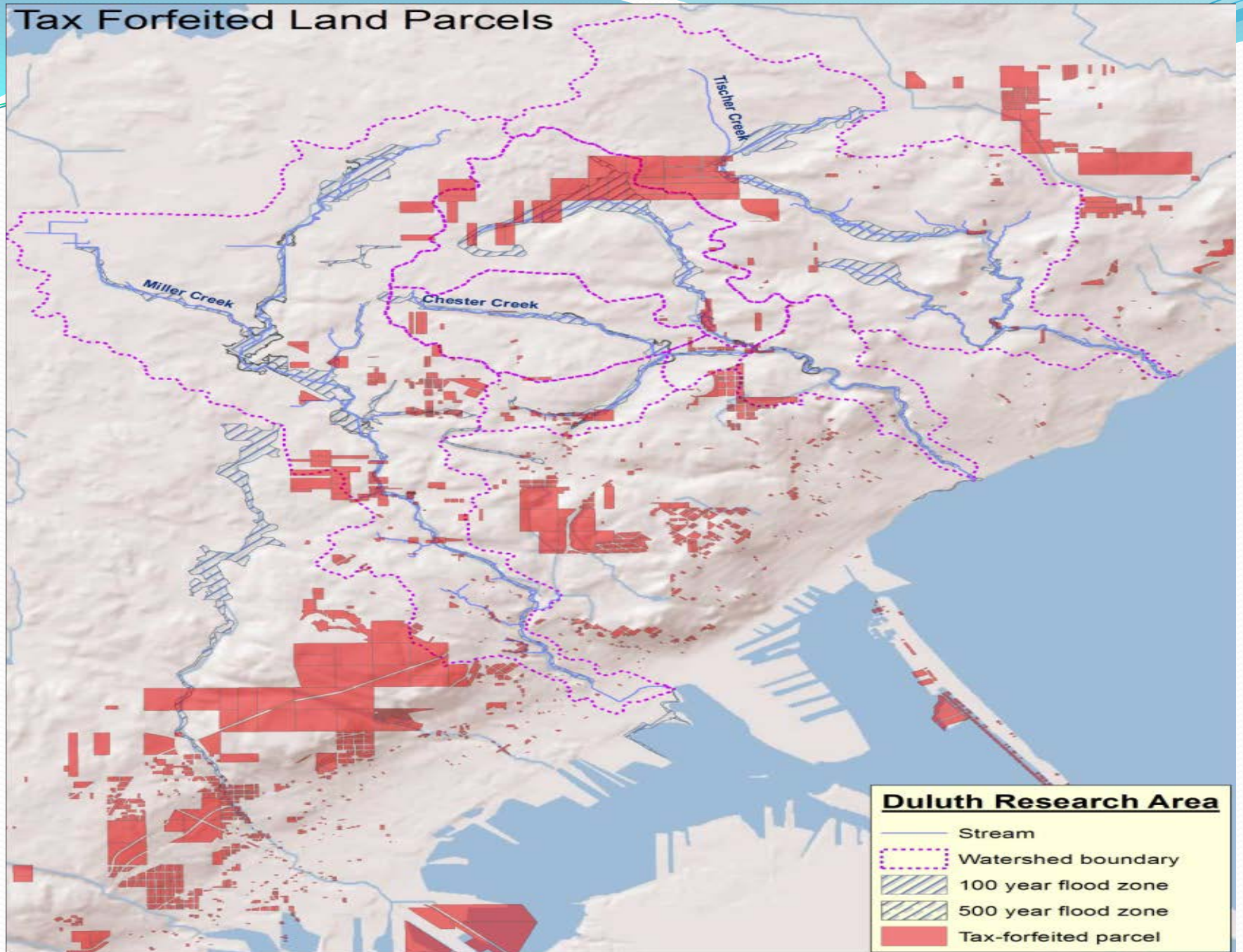
- 30-60% developed in the study area

Duluth: Issues & Considerations

The city estimates approximately $55 million in costs for approximately 700 repair projects needed due to damages from one 2012 storm event

Cost Estimate for Damaged Infrastructure

Miller Creek – $1,596,770
Chester Creek – $1,776,878
   1 - $685,000
   2 - $2,000
   3 - $128,500
   4 - $20,000
   5 - $941,378
Tischer Creek – $1,298,190

Duluth Research Area

Damaged Infrastructure Cost
- ○   < $20,000
- ○ $20,001 - $100,000
- ○ $100,000 - $200,000
- ○ $200,001 - $400,000
- ○   > $400,000
- ▲   Stream damage
- ■   Trail damage
- —   Stream
- ┈   Watershed boundary
- ▨   100 year flood zone
- ▨   500 year flood zone

Tax Forfeited Land Parcels

Duluth Research Area

— Stream
┈┈ Watershed boundary
▨ 100 year flood zone
▨ 500 year flood zone
▊ Tax-forfeited parcel

Current Zoning

Duluth Research Area

——	Stream
····	Watershed boundary
▨	100 year flood zone
▨	500 year flood zone

Zoning

	Form
	Industrial
	Mixed Use
	Mixed Use Commercial
	Residential

Tischer Creek

Miller Creek

Chester Creek

Miles
0   0.5   1   2
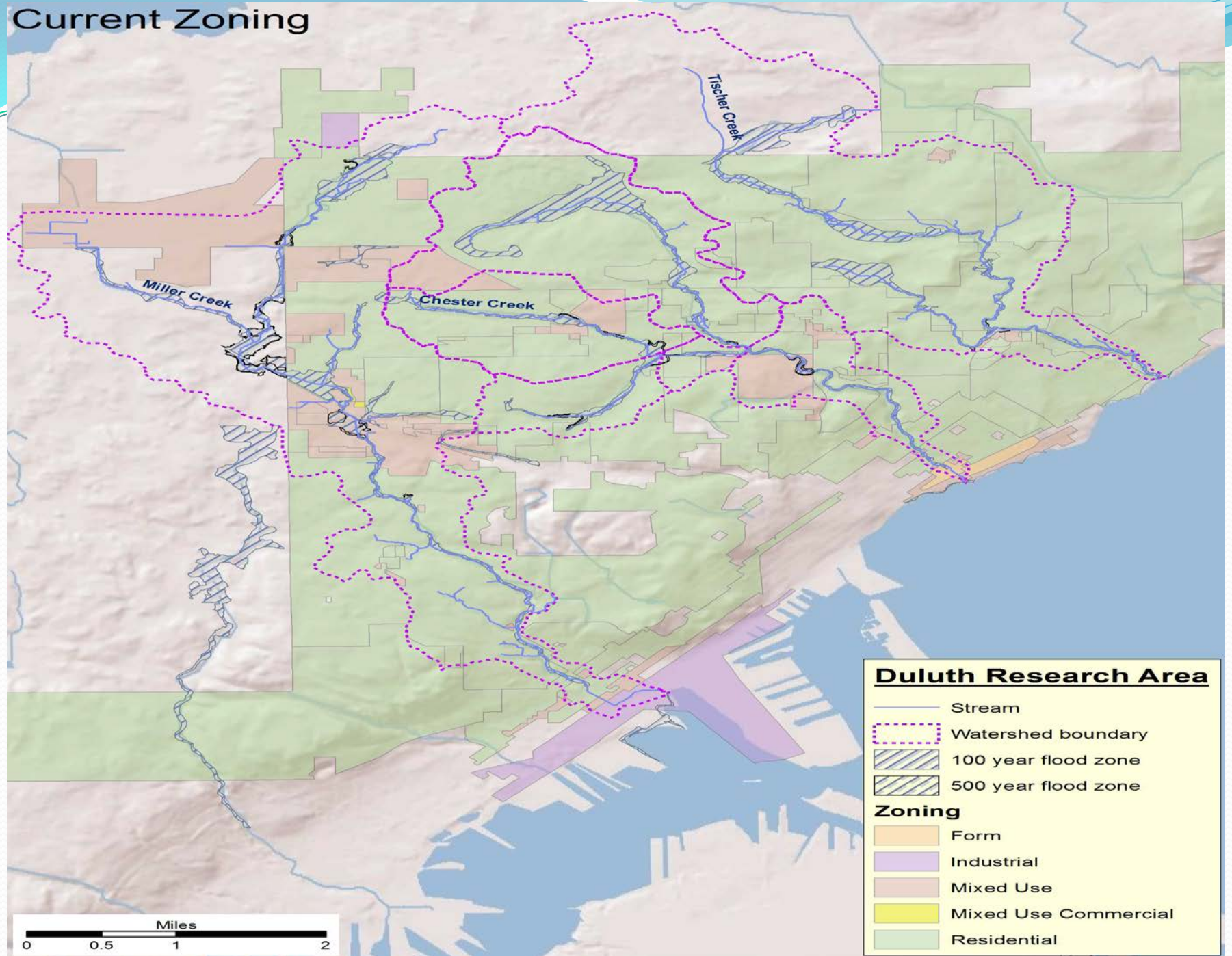
Future Land Use Plans

Duluth Research Area

— Stream
- - - - Watershed boundary
(hatched) 100 year flood zone
(hatched) 500 year flood zone

Future Land Use
- Commercial
- Industrial
- Institutional
- Mixed Use
- Preservation
- Recreation
- Residential/Neighborhood
- Transportation and Utilities

Likely area of study (brown polygon that follows this part of Chester Creek)

Duluth Adaptation Direction to Date:

- Best opportunities are in headwater areas
- Implement larger riparian setbacks to keep development out of floodplains
- Ensure that existing open space in the headwaters area remains undeveloped where possible (easements, zoning, land acquisition)
- Increased storage in headwaters to reduce flooding downstream (number of GI options)
- Next: We will compare costs including lost tax revenue for land use and GI options chosen

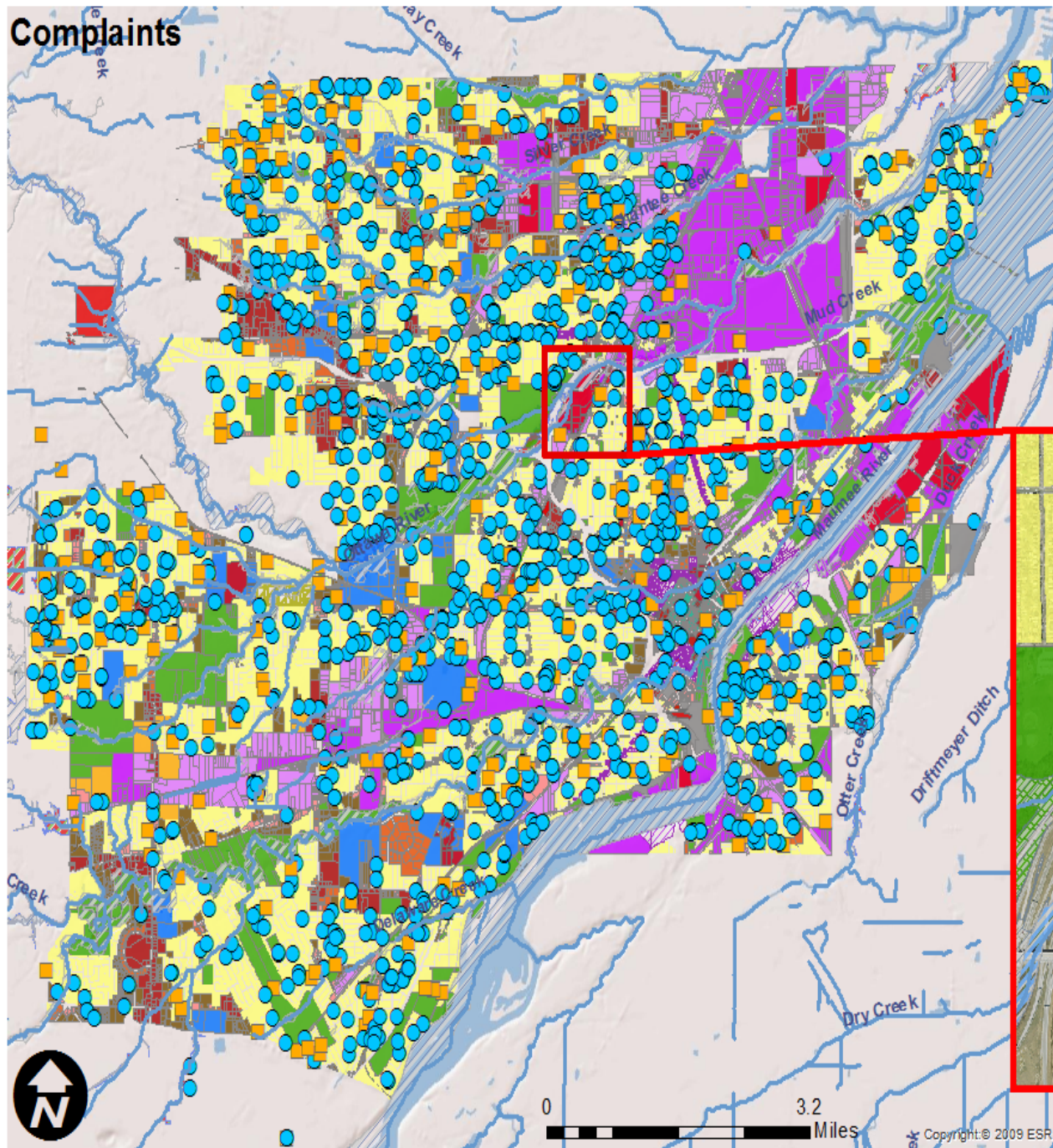# Toledo: Issues & Considerations

- Relatively flat topography
- Development up to the floodplain (highly developed)
- Development pressure in floodplains
- High population density (~4,000 people/square mile)
- Rampant basement and street flooding ("ponding everywhere") even in small storms
- Undersized, traditional stormwater infrastructure
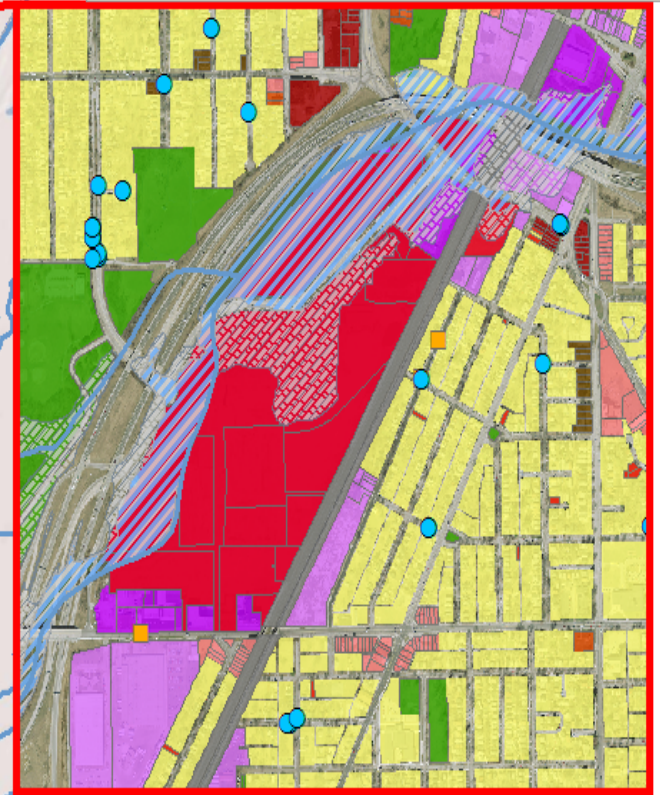
Toledo Flooding, 2012

Credit: David Stowell, www.examiner.com, March 16, 2012

Complaints

Toledo Research Area

—— Rivers & streams	▨ Parks & Open Space
▨ 100-year flood zone	■ Institutional Campus
▨ 500-year flood zone	■ Neighborhood Commercial
● Water Standing in Street	■ Office Commercial
■ Water Standing Other	■ Regional Commercial
■ Tax forfeited parcels	■ Light Industrial
Future land use	■ Heavy Industrial
▨ Urban Village	■ Utilities
■ Single Family	▨ Off. Research / Lg. Lot Res.
■ Multi Family	▨ Urban Agriculture
■ Manufactured Housing	■ Downtown Commercial

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0   3.2   Miles

0   0.4   Miles

Toledo Adaptation Direction to Date

- Future land use plans indicate increased density/impervious surface
- Opportunities=smaller scale parcels in the floodplain
- Localized solutions (pocket flooding): focus on implementing GI/restoration on tax title land and incorporating GI into future development/redevelopment (zoning and building codes)
- Property buy outs: residential properties with chronic flooding within the floodplain

Lessons Learned: Challenges and Opportunities

- Data and Modeling Challenges:

  - When is the optimal time to collect data v engage with stakeholders?
  - Using existing models usually saves $
  - Data collection is expensive and existing data hard to find/assemble
  - Clean handoff from model outputs to model inputs

- Respect local context: economic, hydrologic, political realities

- Opportunities for long term policy changes relating to land use in these cities though at different scales and magnitude of results

- Opportunities to consolidate data and develop baseline analysis to inform future investment and land use decisions

Lessons Learned for Transferability

LOCATION, LOCATION, LOCATION

- Develop site selection criteria in advance
- Need adequate baseline (flooding data sets, previous modeling, previous flooding damage costs)
- Look for availability of opportunities (land availability, political support) for range of options to be considered

PARTNERSHIPS, PARTNERSHIPS, PARTNERSHIPS

- Know how information flows within a community
- Love your local POCs that provide access to data/info
- Build capacity in town for future

Next Steps

- Finish model runs
- Propose GI and land use adaptation options for each community
- Economic analysis comparing options
- Identify/quantify co-benefits
- Draft report for transferability to other communities
- Inform community planning guide on economic analysis of resilient infrastructure (in progress)

Project Team

- **NOAA COASTAL SERVICES CENTER**
  - Jeffrey Adkins, Economist and Project Manager
  - Nancy Cofer-Shabica, Coastal Conservation Specialist
  - Laurie Cary-Kothera, Physical Scientist

- **EASTERN RESARCH GROUP**
  - Arleen O'Donnell, Project Manager
  - Ellie Codding, Technical Lead/Deputy Project Manager
  - Lauren Scott, Engineering
  - Martina McPherson, GIS

- **ASSOCIATION OF STATE FLOODPLAIN MANAGERS**
  - Jeff Stone (HAZUS modeling)

- **HORSLEY WITTEN GROUP**
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